Utility Systems Integration

Grid Interface Model Development

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FY 2004 DOE Wind Program Implementation Meeting
November 16 -18, 2004
Omni Interlocken Hotel
Broomfield, Colorado

Typical Utility Planning/Concerns

- Load Flow (steady state)
  - Thermal limit (contingency analysis)
  - Voltage collapse (reactive power requirement)
- Power System Stability (dynamic-disturbance)
  - Rotor angle stability
  - Frequency stability
  - Voltage stability
- Unlike conventional single generator power plants, wind plants have many generators with individual controls operating at non-uniform power levels.

Issues

- Utility planners need validated dynamic model of wind turbines for interconnection studies.

- Not all wind turbines have models available.

- The wind plant models available have not been validated.

- Validation needs high speed data not currently and/or easily available.

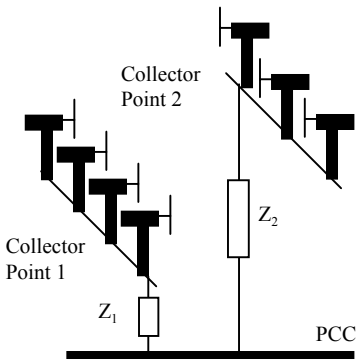
- Hardware and control are constantly changed and improved by the manufacturers.

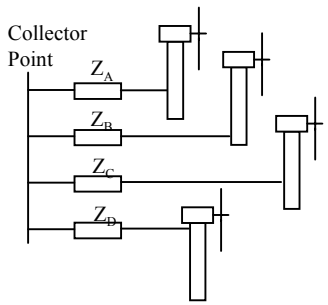
Addressing the Issues

- Validation of Dynamic Model
  - Monitor events, locate fault, reproduce fault on simulation, compare results
- Collaboration strategy:
  - Seek unique grid/wind plant configurations that challenge models yet are representative and illustrate sound modeling practice
  - Seek partners with mutual interests
- Tight coordination with UWIG User Groups
  - Wind Plant Modeling and Interconnection User Group
  - Operating Impact and Integration Study Work Group
  - Distributed Wind Applications Work Group
  - Market Operation and Transmission Policy User Group

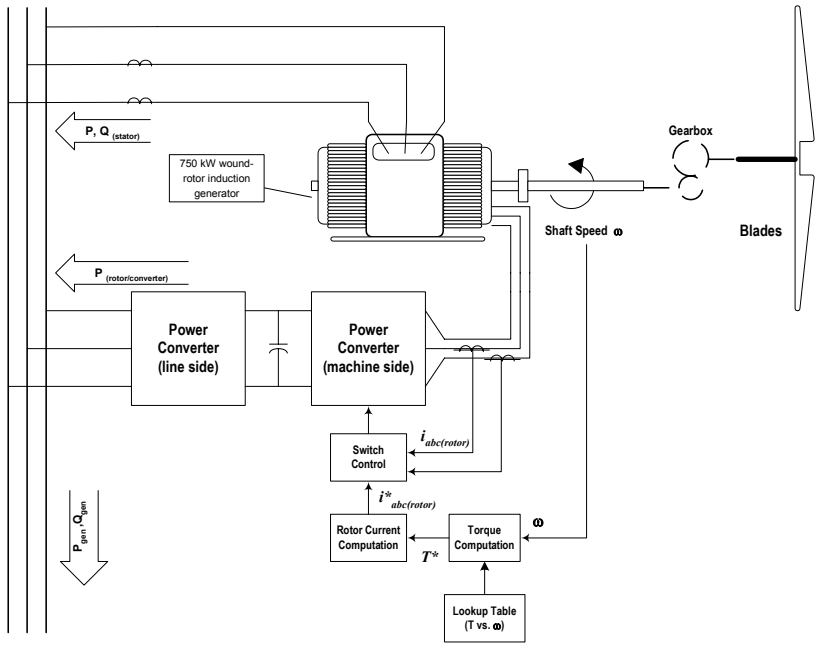
Scope of Grid Interface Model Development

- aerodynamic
- mechanical (shaft, gearbox, inertia)
- generator – power converter
- control system
- electrical grid
- relay protections
- aggregation in a wind farm
- wide-area control

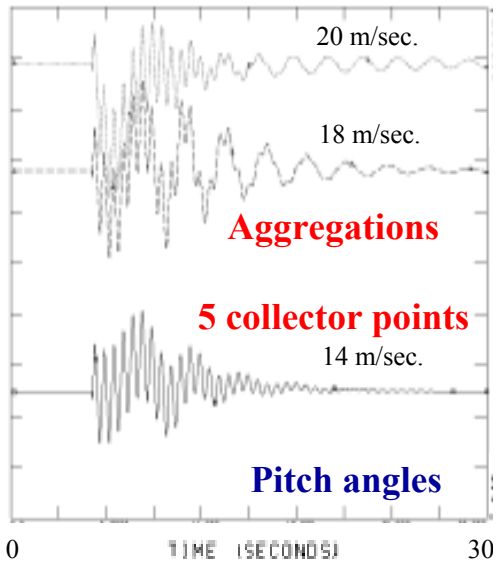


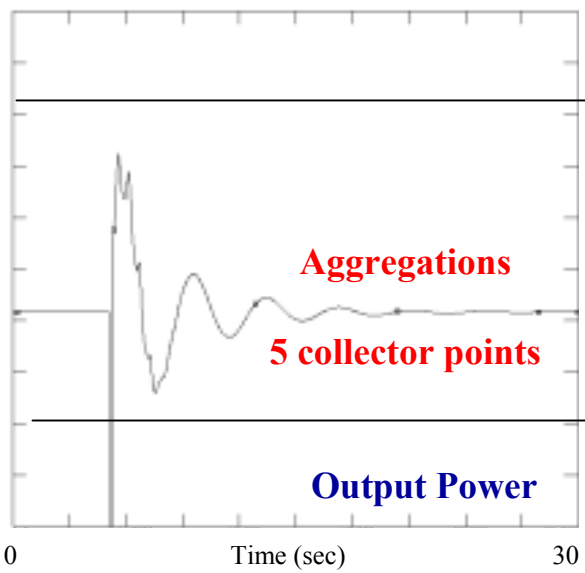


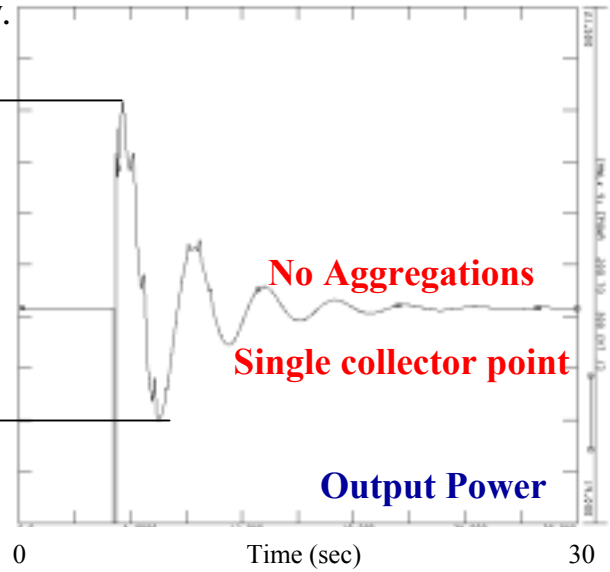
Power System Network

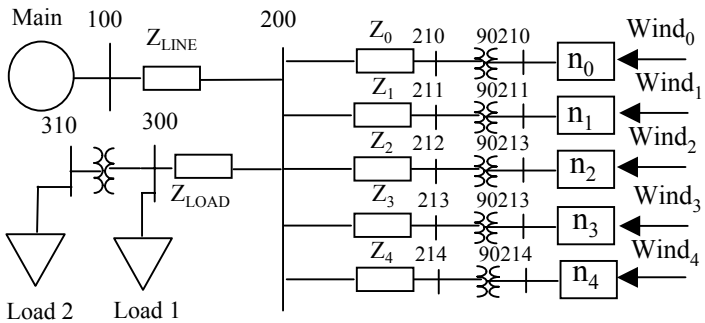


Scope of Grid Interface Model Development

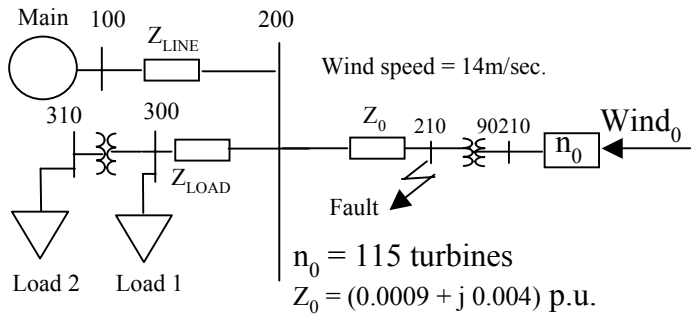






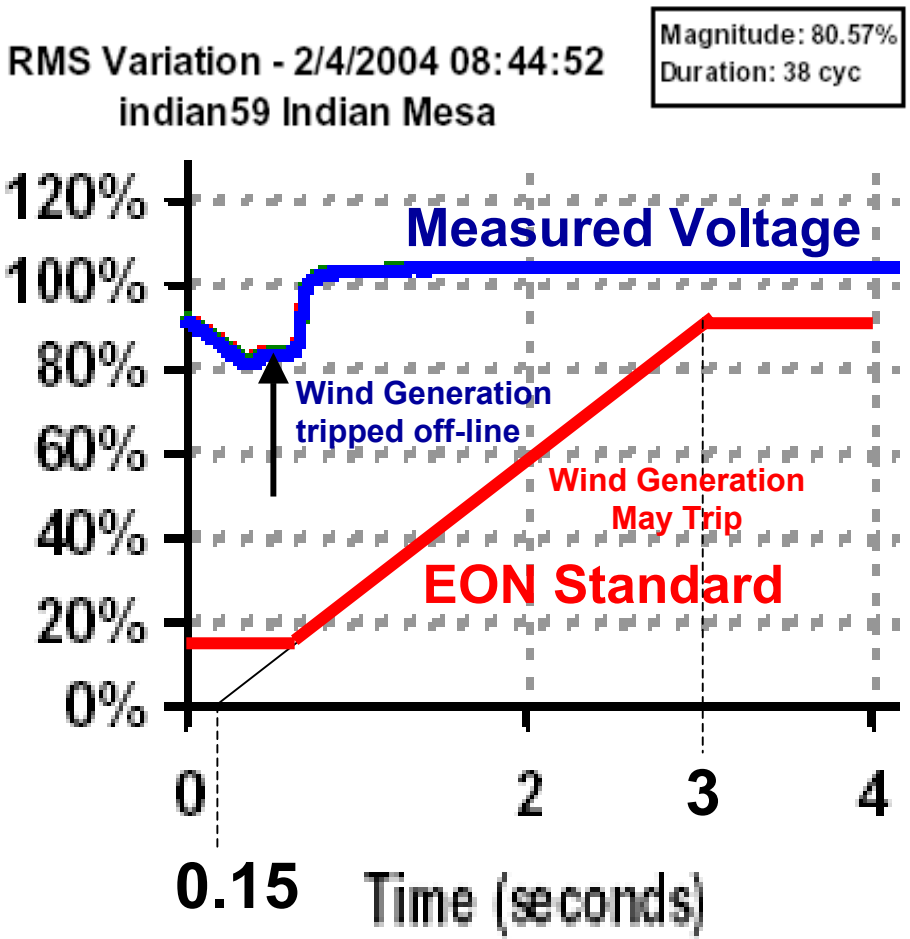


Aggregations: 5 collector points



No Aggregations: Single collector point

EON Standard for LVRT at Grid Interconnection Proposed by AWEA



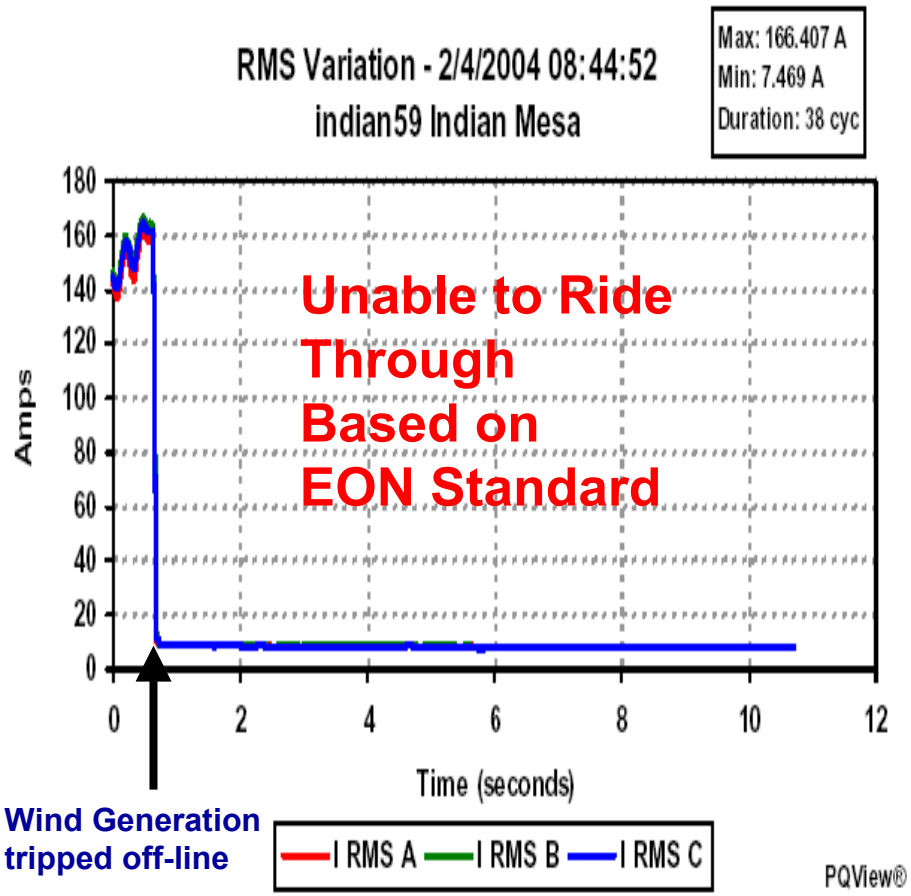


Figure 43: RMS Variation Current 2/4/2004 08:44:52

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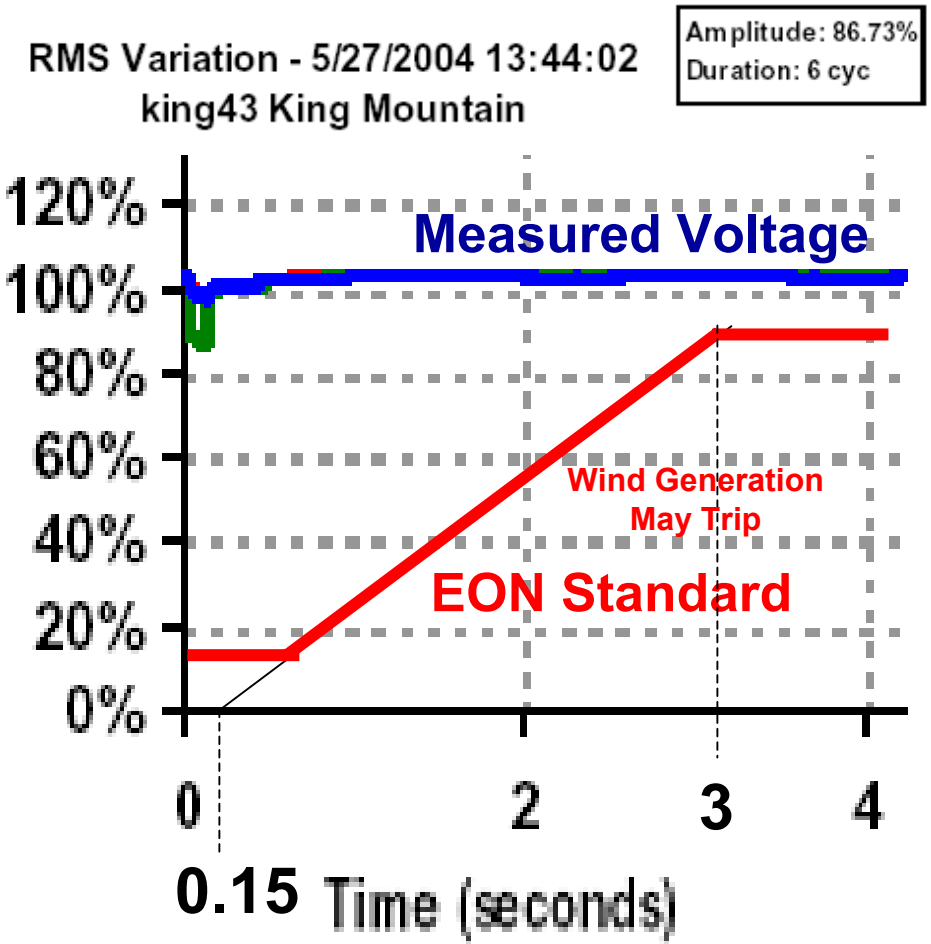

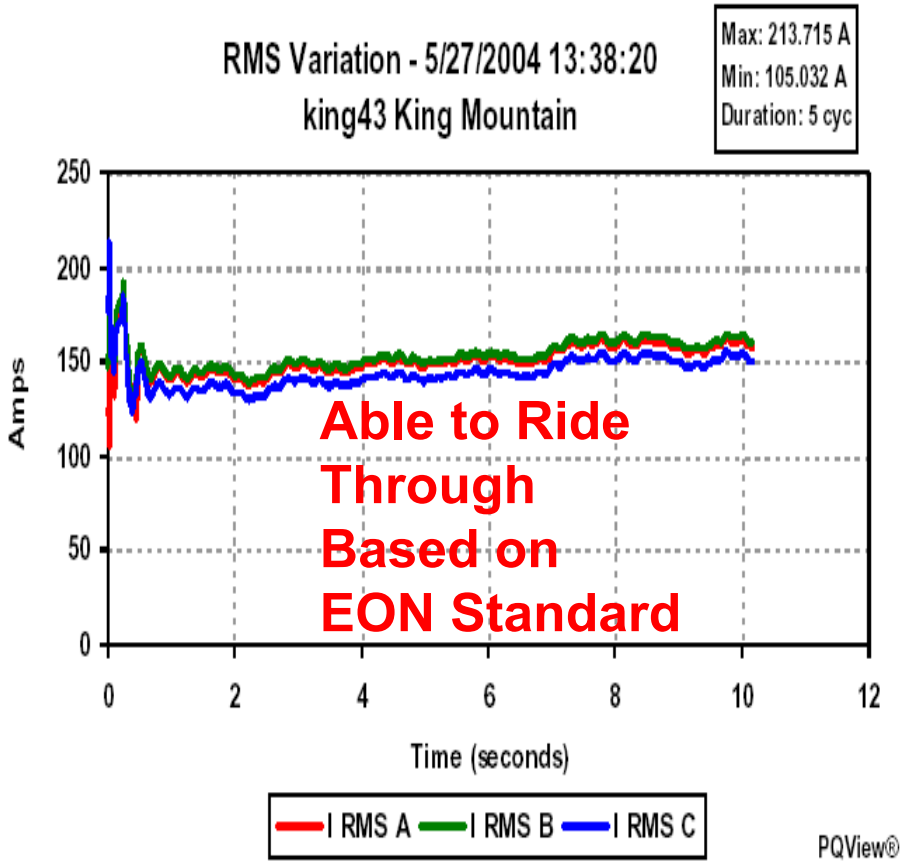

Figure 39: RMS Variation Current 5/27/2004 13:38:20

Collaborations

Collaborative efforts

- Tehachapi Wind Farm Evaluation:
  - Southern California Edison and Oak Creek Energy
  - Voltage Collapse, Reactive Power, Energy Storage, Self Excitation and Harmonics Issues – completed
- Validation of ERCOT's PSSE Models:
  - Models GE, NEG Micon NM72, Bonus1300, MVS330, Vestas V80
  - Run simulations on single turbine bases – completed
  - Run simulations on the entire ERCOT power systems – completed
  - Verifications on the ERCOT power system network with actual data measurement – in progress

Future Collaborations

Wind Farm at Taiban Mesa, New Mexico

- Participants: Public Service of New Mexico, Florida Power and Light, General Electric and Utility Wind Interest Group
- Scope: turbine model verification and wind farm aggregation

Wind Farm at Wyoming Energy Center, Uinta County, WY

- Participants: PacifiCorp, Florida Power and Light, Shaw Power Technologies (PTI), Vestas, NREL
- Method: passive fault event monitoring, long term monitoring